Determination of Root Distribution, Dynamics, Phenology and Physiology of Almonds to Optimize Fertigation Practices

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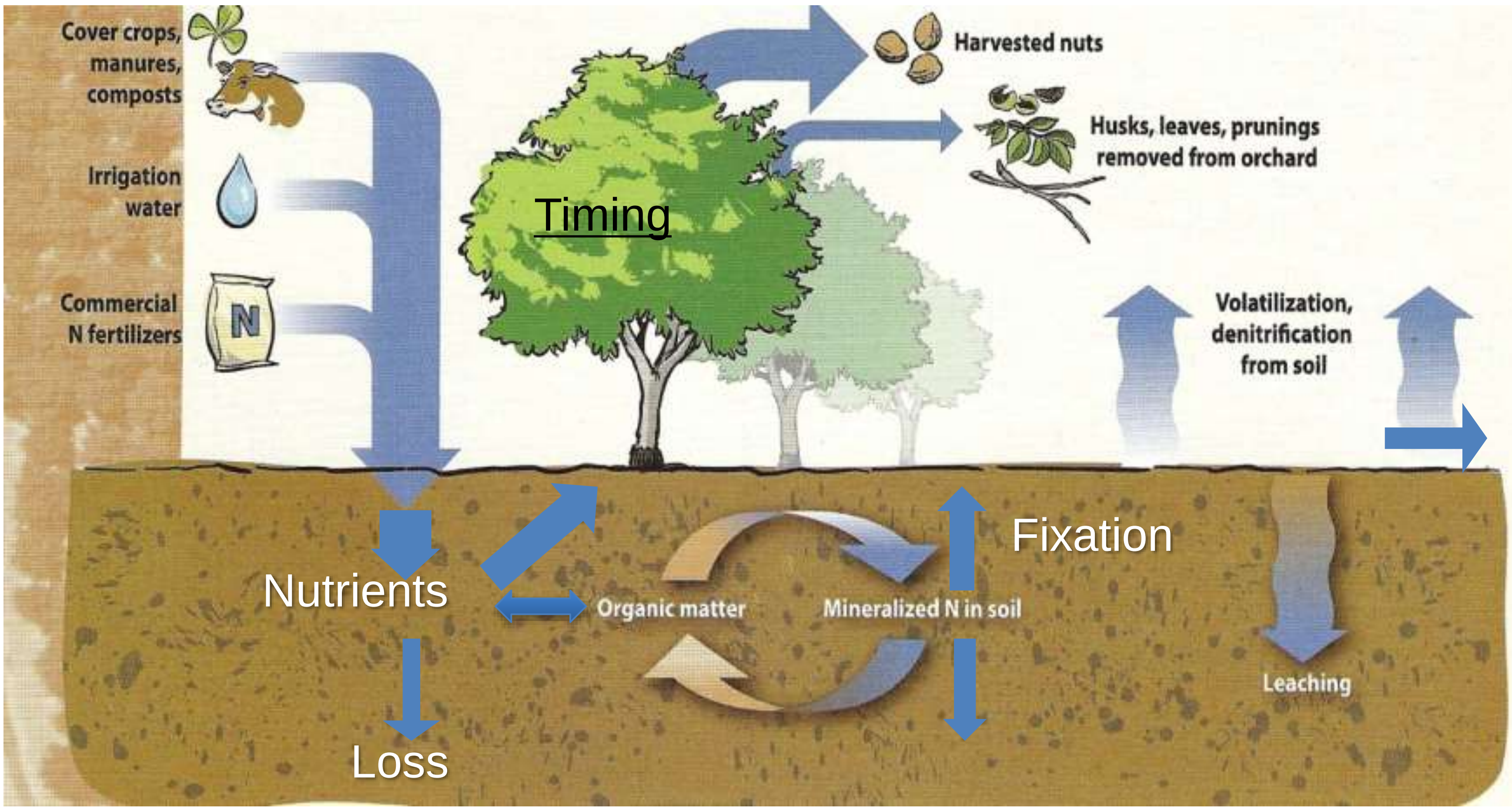
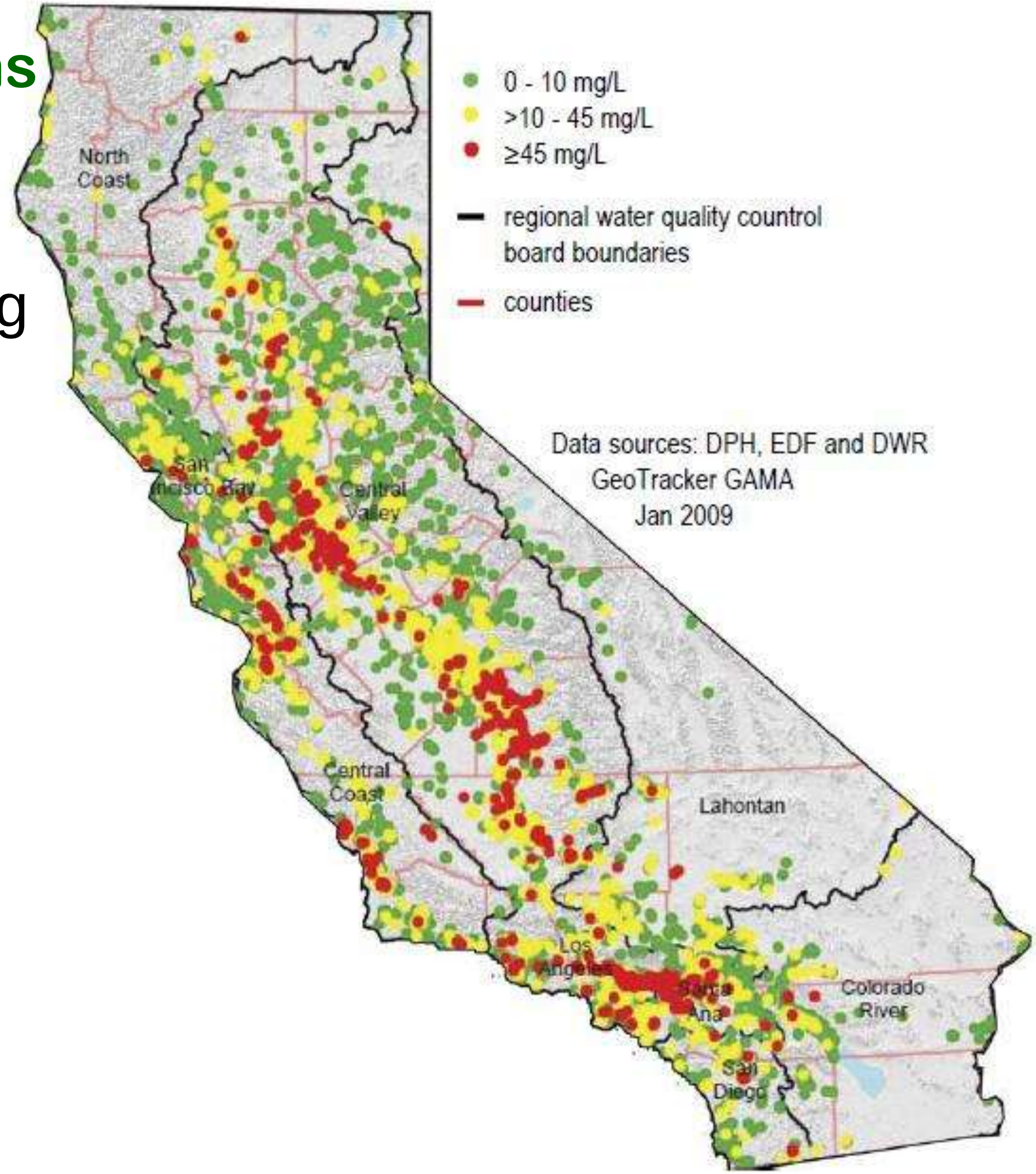
Managing Nitrogen in Perennial Crops

<u>Supply (Rate)</u> <u>Demand (Amount and Timing)</u>

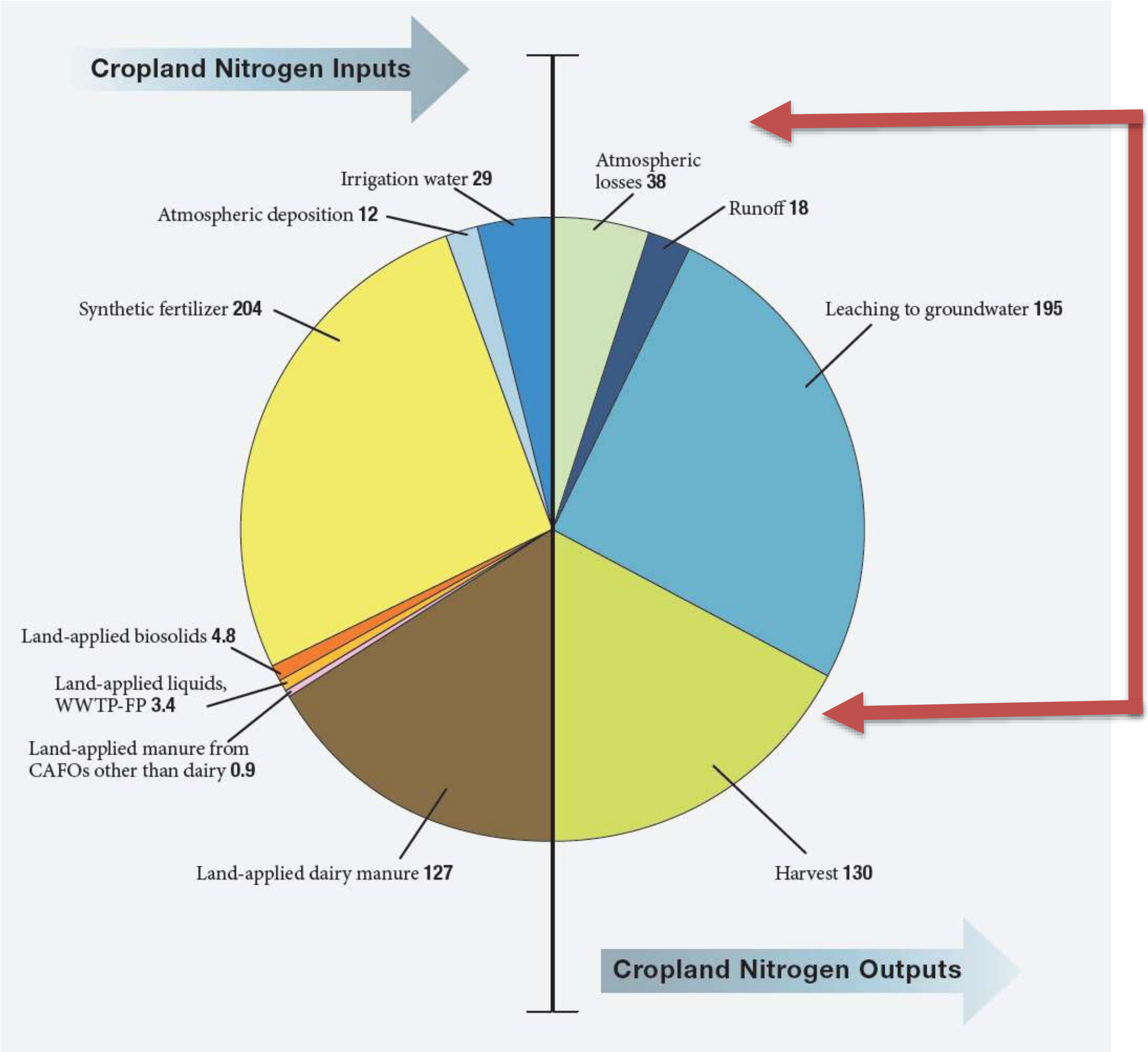


Environmental concerns

Nitrate concentrations in many California wells exceed EPA drinking standards.



(Ekdahl and others, 2009)



253 giga Ton

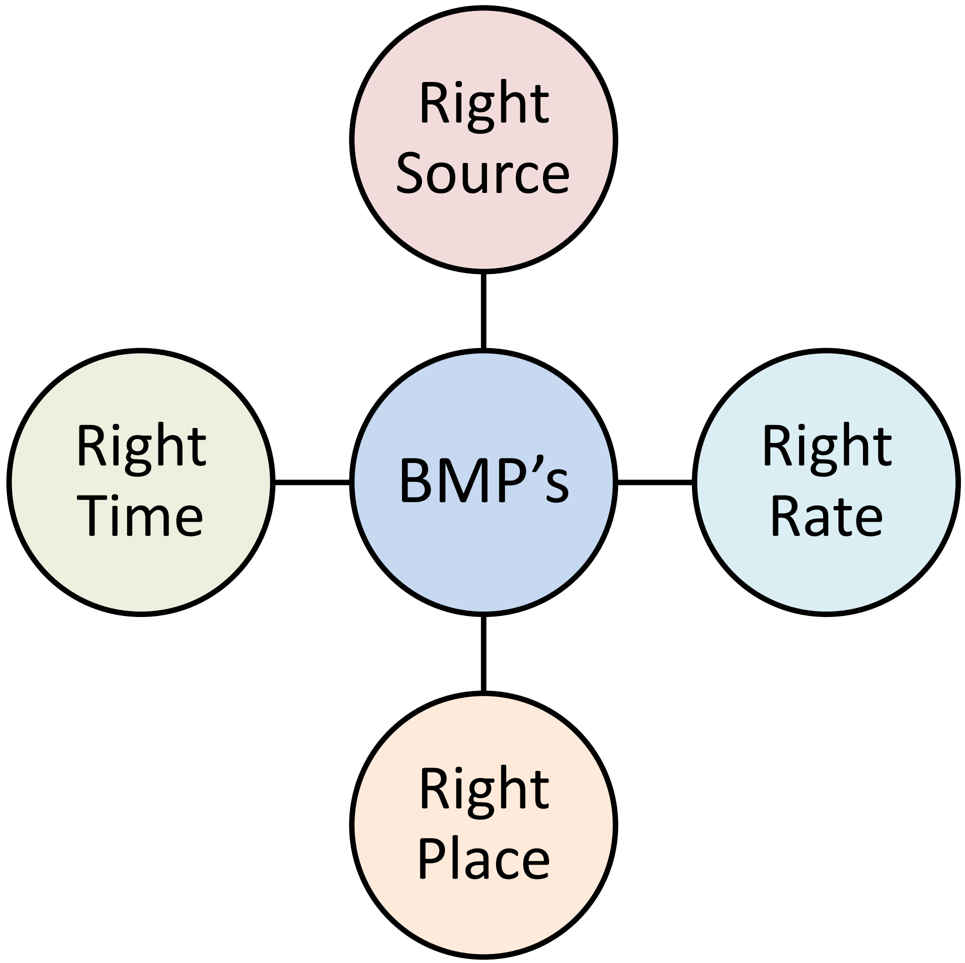
66% of applied N is not present in the harvested crop and is at risk for loss.

Legislative Response: Mandated Nitrogen Management Planning

- **Application rates will be based upon field specific crop N budget demand (replace off take) and accounting for all sources of N (irrigation, OM, soil residual N).**
- **Certified Crop Advisor sign off required.**
  - Training Requirement
- **Post season verification and reporting.**
  - Collated and Managed by Local Water Coalitions

To achieve optimal productivity with restricted nitrogen will require enhanced efficiency of N use.

Optimal Fertilization Practices



I.F.A., 2007

Main goal = Match supply with demand

Determining Nitrogen Demand in Trees

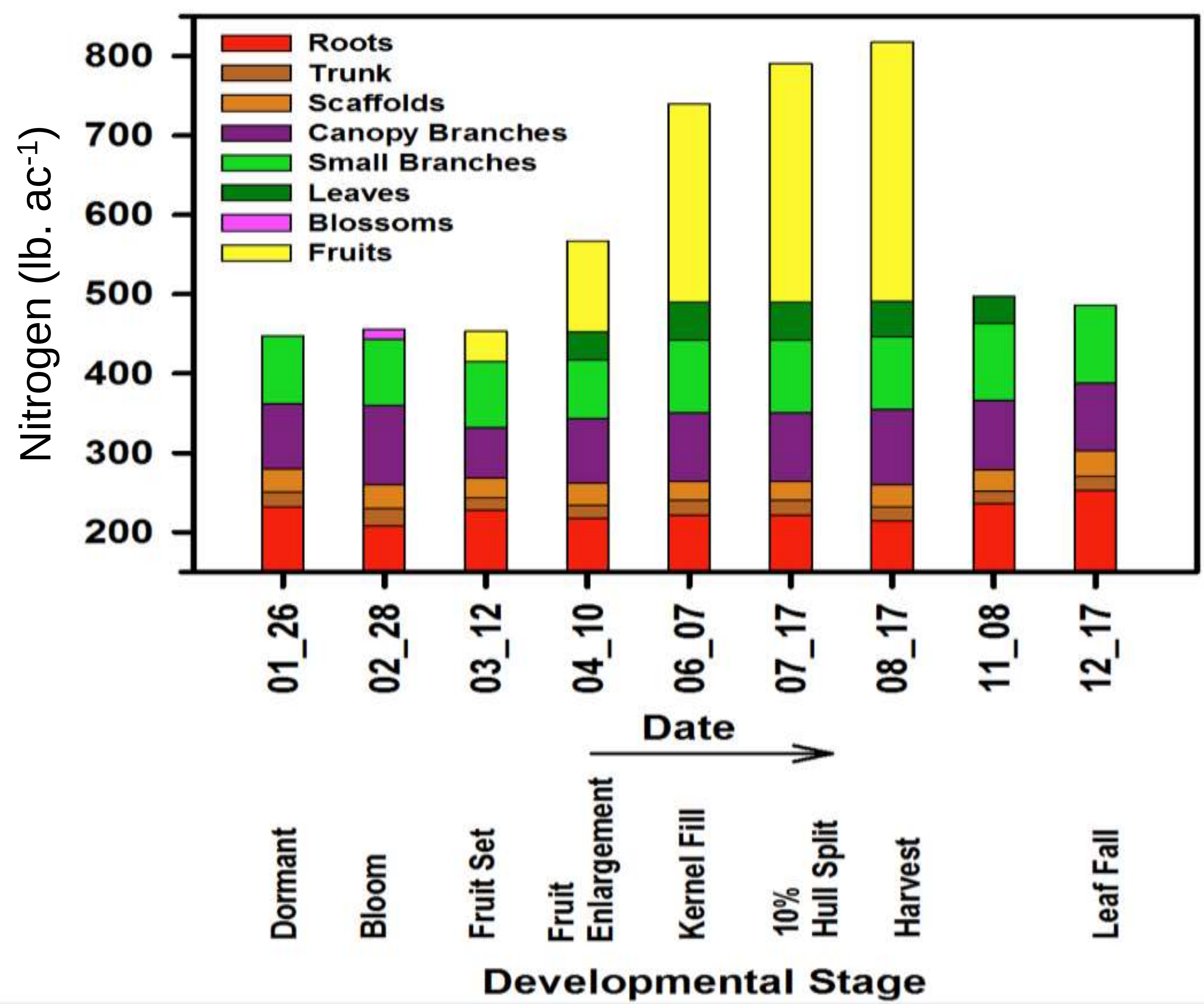
(Californian data for Almond, Pistachio, Walnut, Grape, partial for Prune)

Collection, Separation and Analysis of Annual Tissues

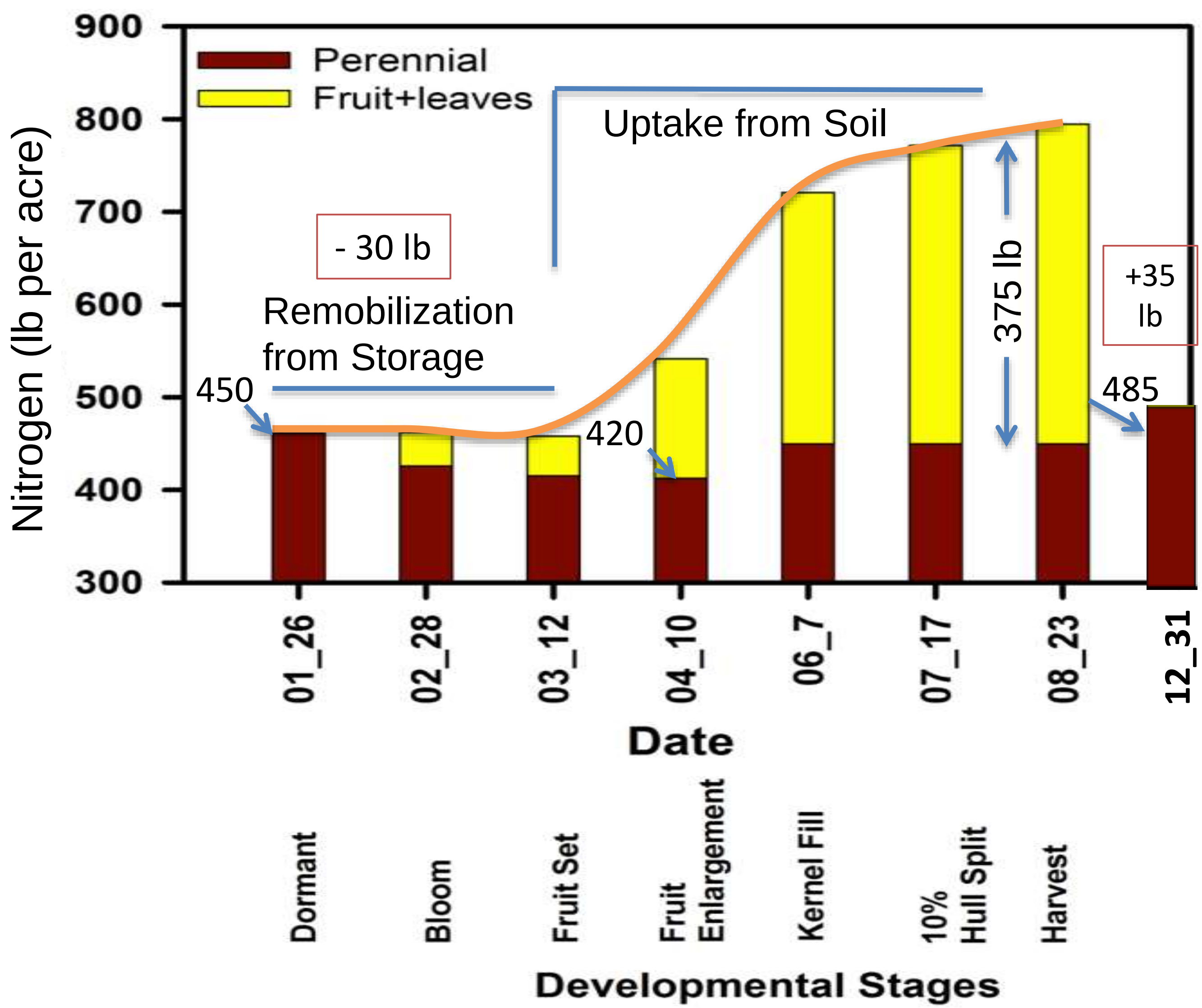
Tree Excavation, Partitioning, and Analysis of Perennial Tissues

Muhammad, PhD Dissertation. 2013

Nitrogen Dynamics (12th leaf tree 4,800 lb.)

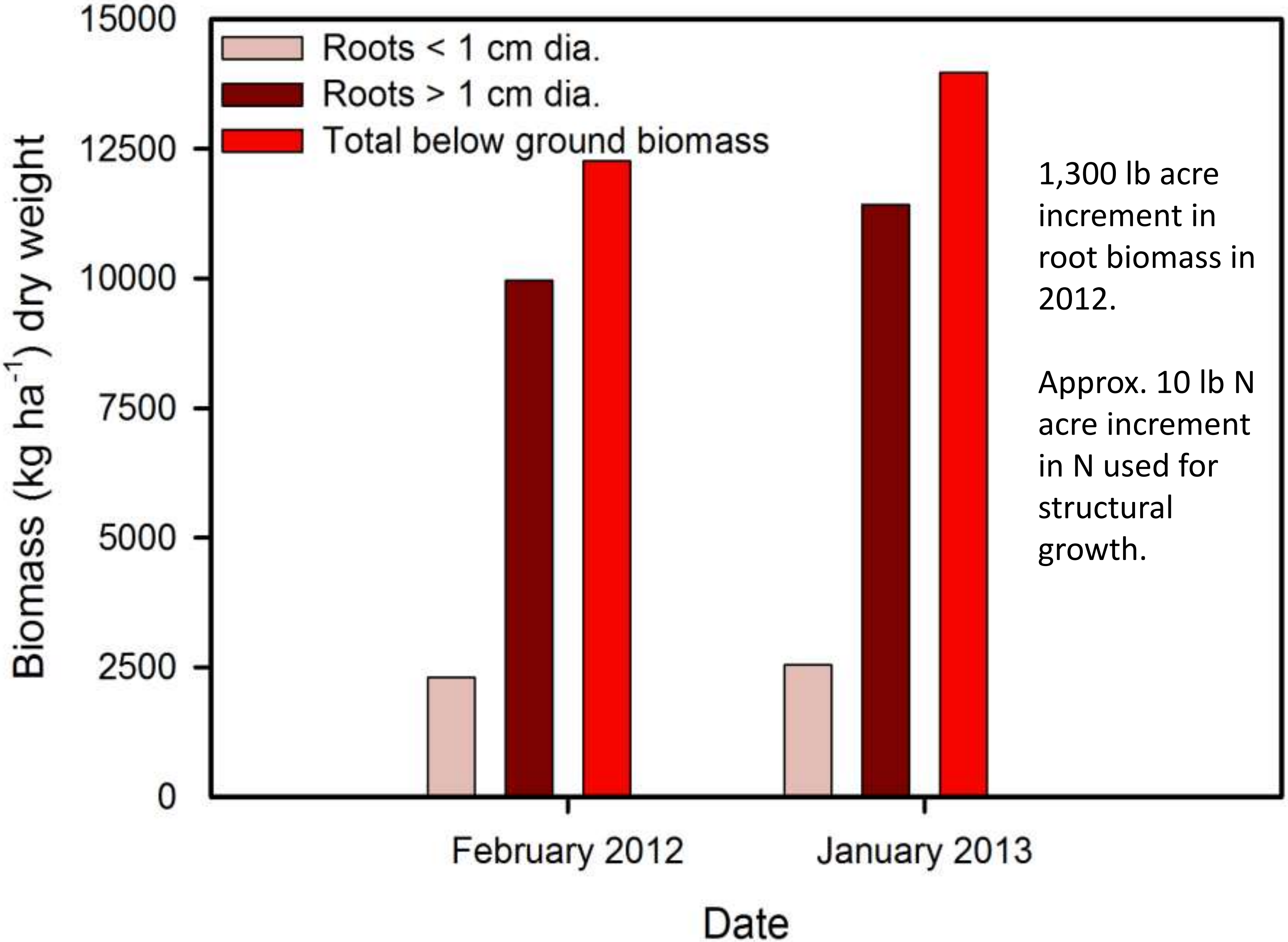


Total and Annual Dynamics of N in Mature Almond (data from 11-12 year old trees 4,800 lb)



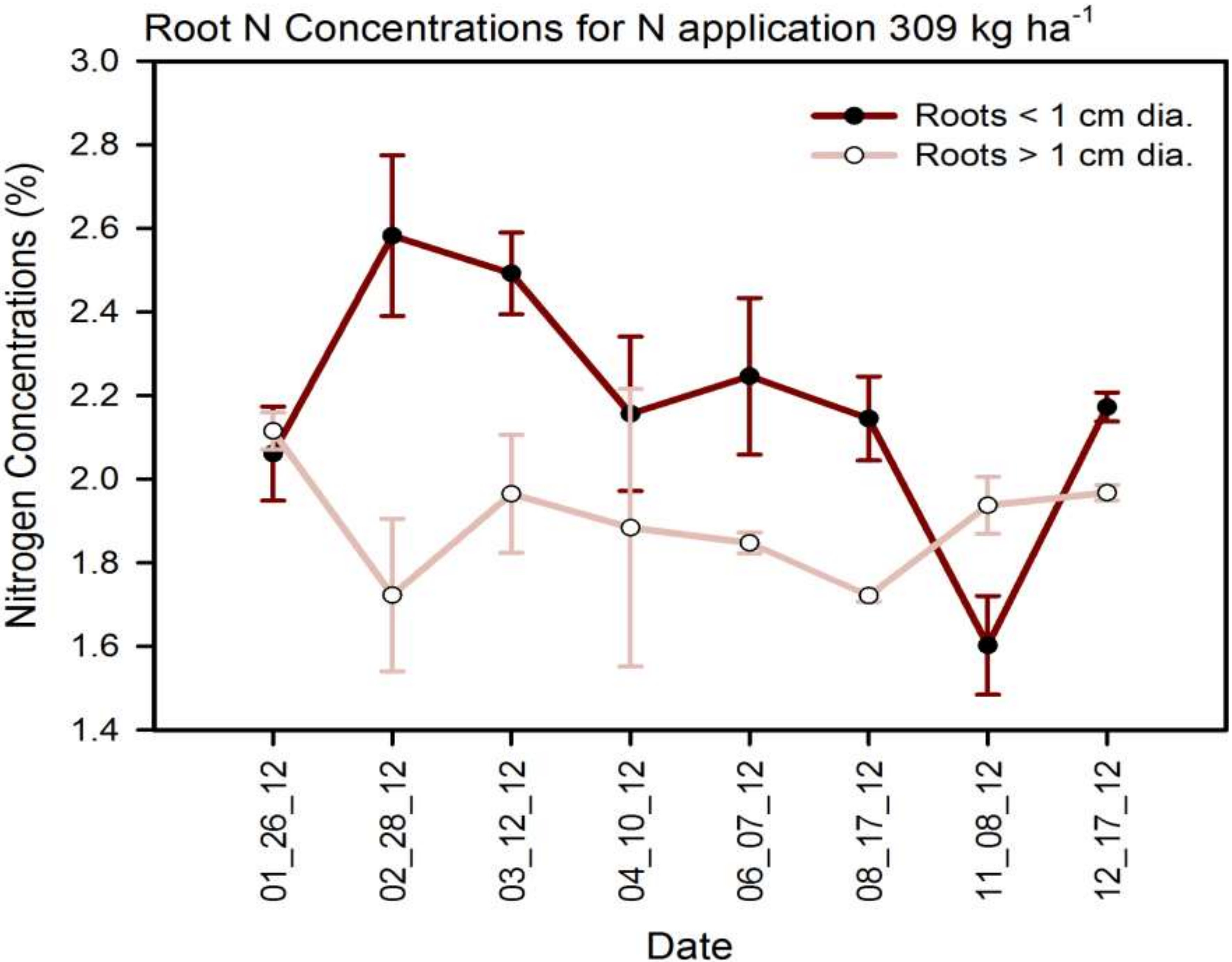
80% of perennial tissue is above ground.

Between 10 and 20 lbs. N per acre per year for new perennial above ground growth.



1,300 lb acre increment in root biomass in 2012.

Approx. 10 lb N acre increment in N used for structural growth.



Root N Concentrations for N application 309 kg ha-1
Nitrogen Concentrations (%)
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
Roots < 1 cm dia.
Roots > 1 cm dia.
01_26_12
02_28_12
03_12_12
04_10_12
06_07_12
08_17_12
11_08_12
12_17_12
Date

Rate and Time of Uptake

- From dormancy to mid-leafout there is very little N uptake.
- Nitrogen stored in perennial tree parts is used to provide N for flowers, fruits, leaves and new roots.
- Uptake commences at mid-leaf out and is essentially complete by hull split.

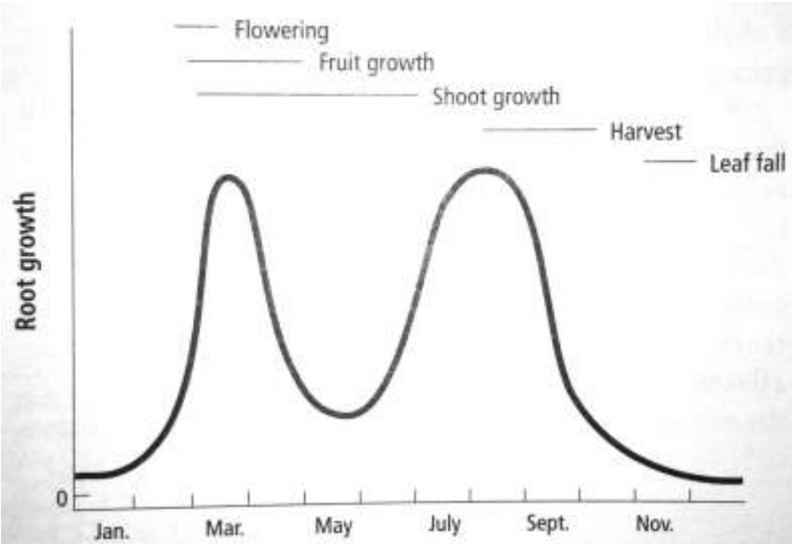
<u>Perennial N: (12 year old 90% full canopy trees)</u>

- 450 lb N/acre in dormant perennial organs in January (includes labile stored N)
- 420 lb N/acre in perennial organs in March (30 lb N acre remobilized).
- 35 lb accumulated in perennial N over 12 months (50% from leaf remobilization).

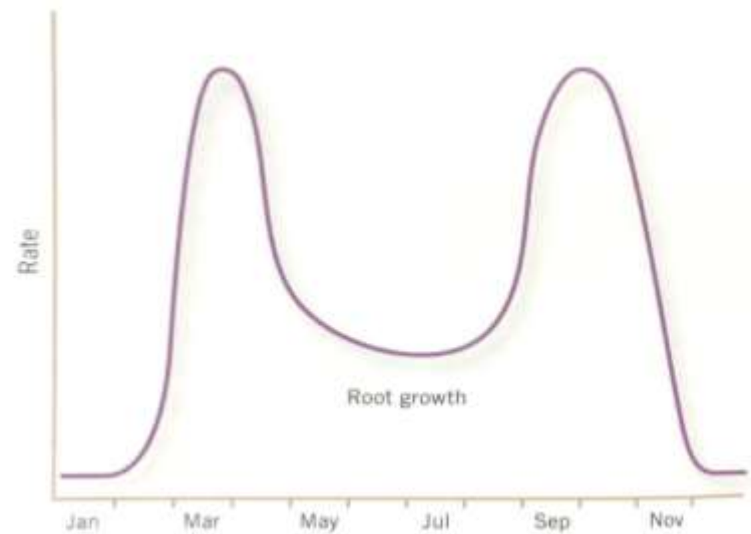
When Does New Root Growth Occur?

What is the pattern of root growth?

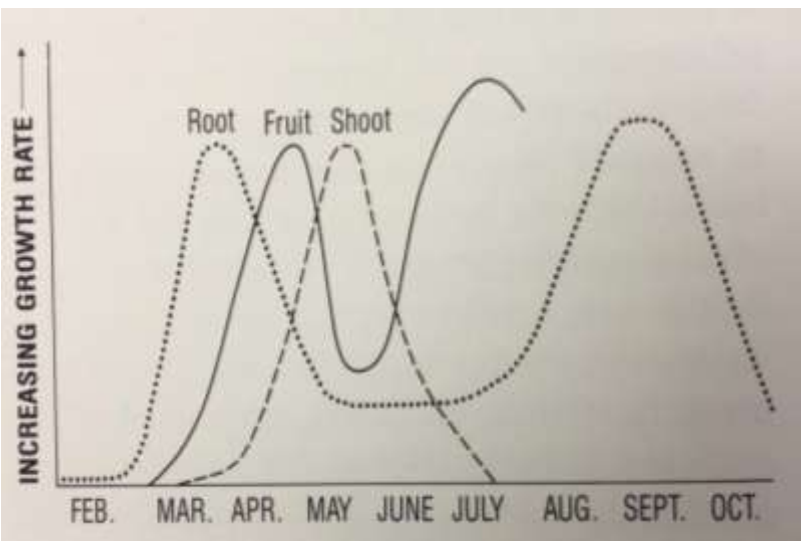
Almond 1998



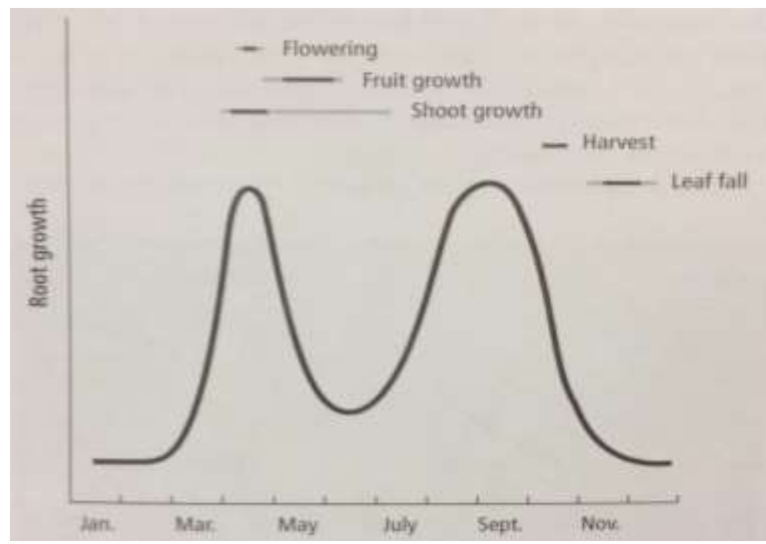
Prune 2012



Peach 1989

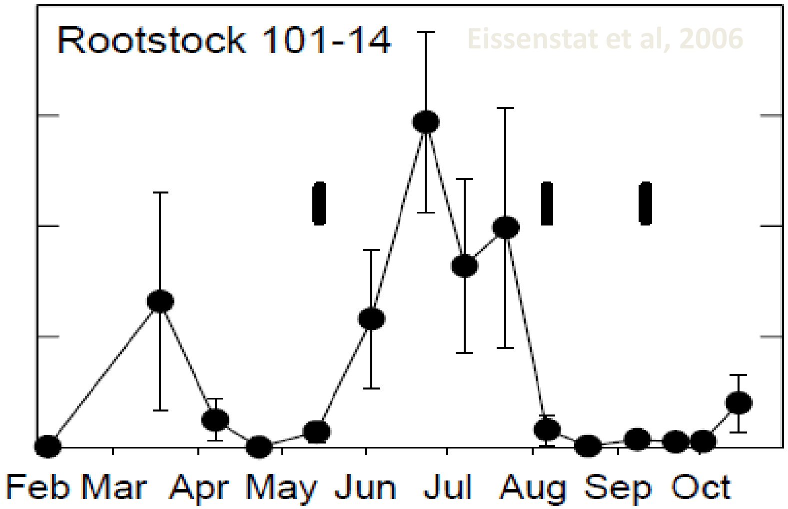


Walnut (1977, 1998

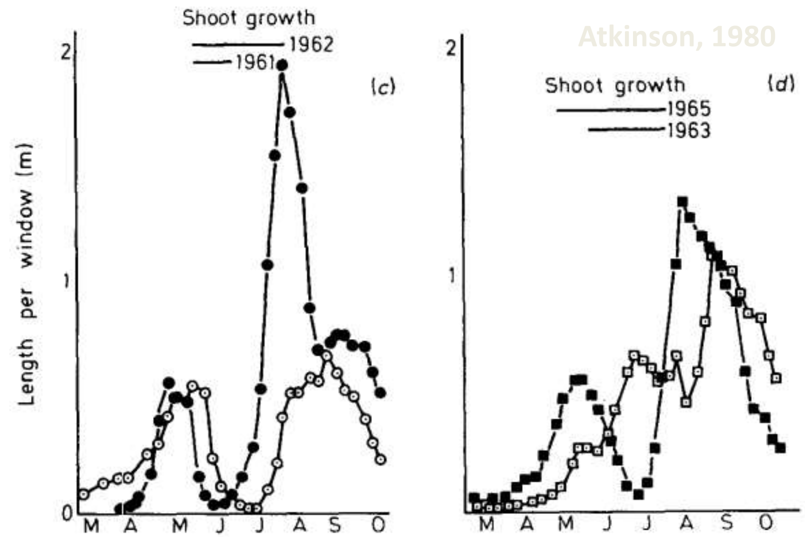


What is the pattern of root growth?

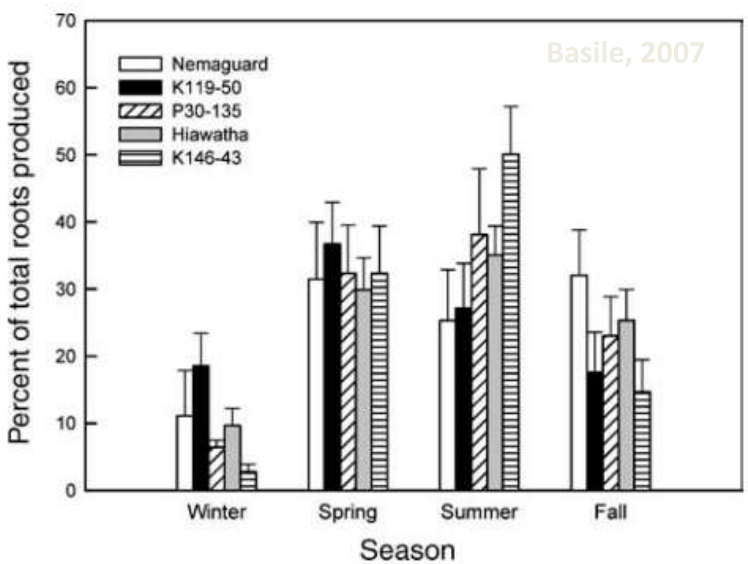
Vines (Merlot)



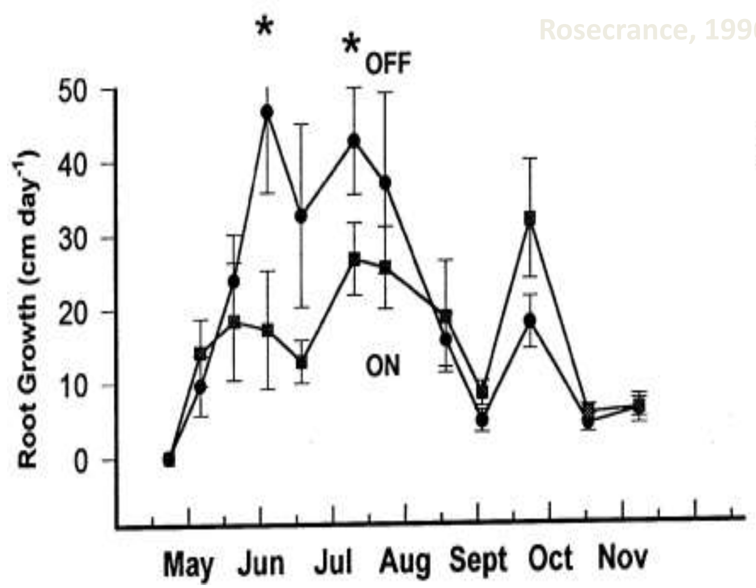
Apples



Peach

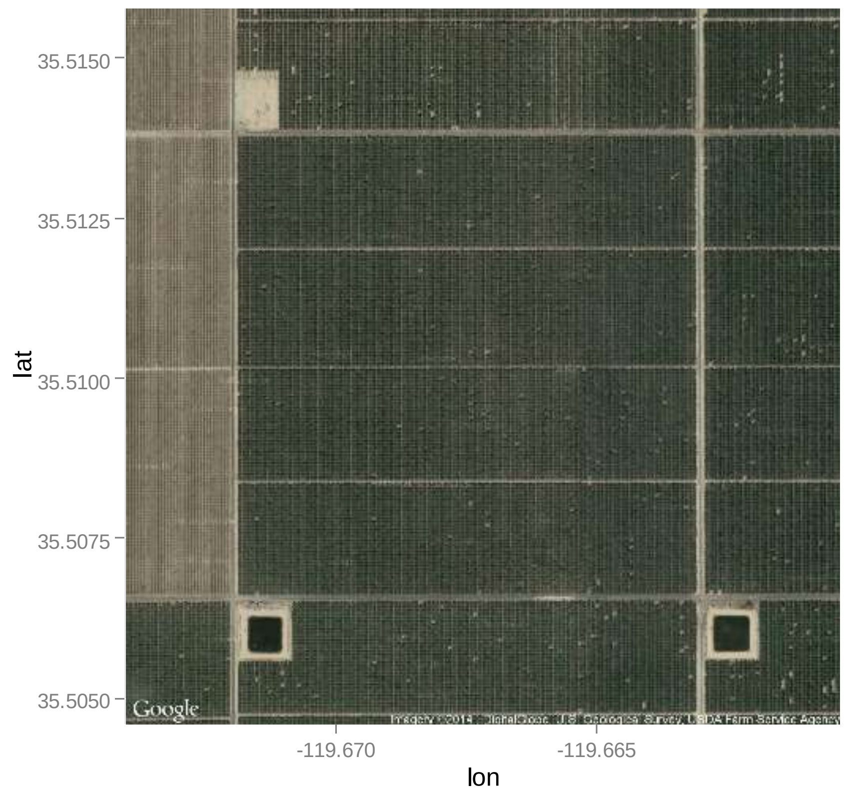


Pistachios

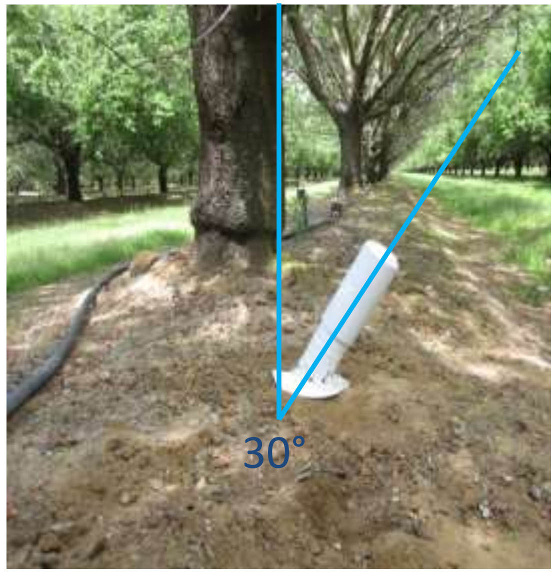


Project Settings

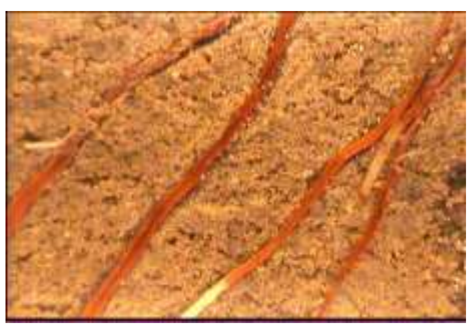
- High producing 13 year old Orchard in Kern County
- Nonpareil/Monterey
- 87 trees/ac

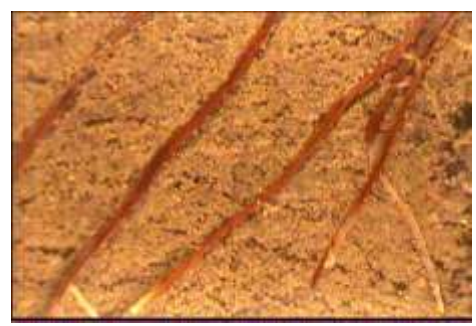


Root phenology



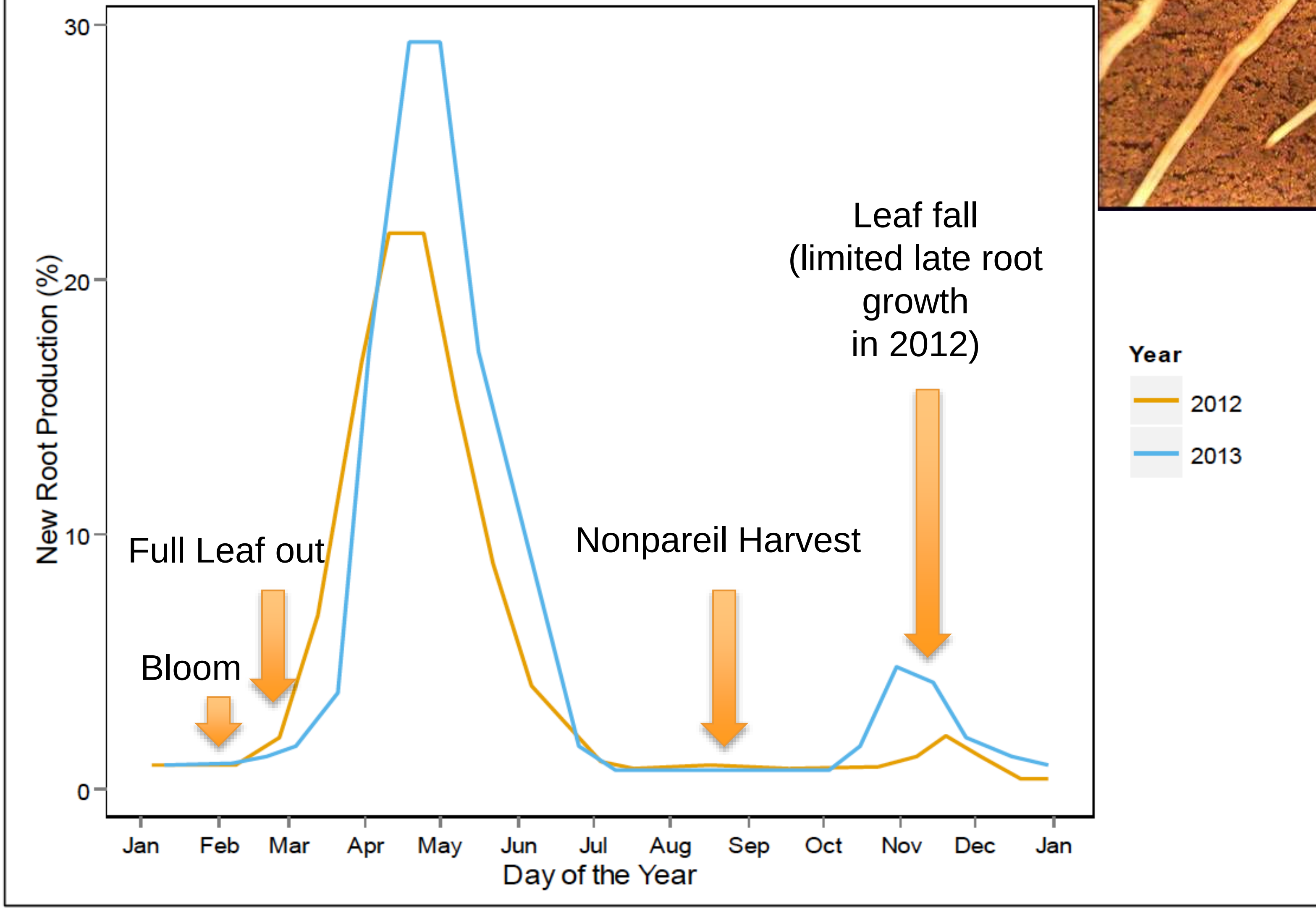

05/03


05/16

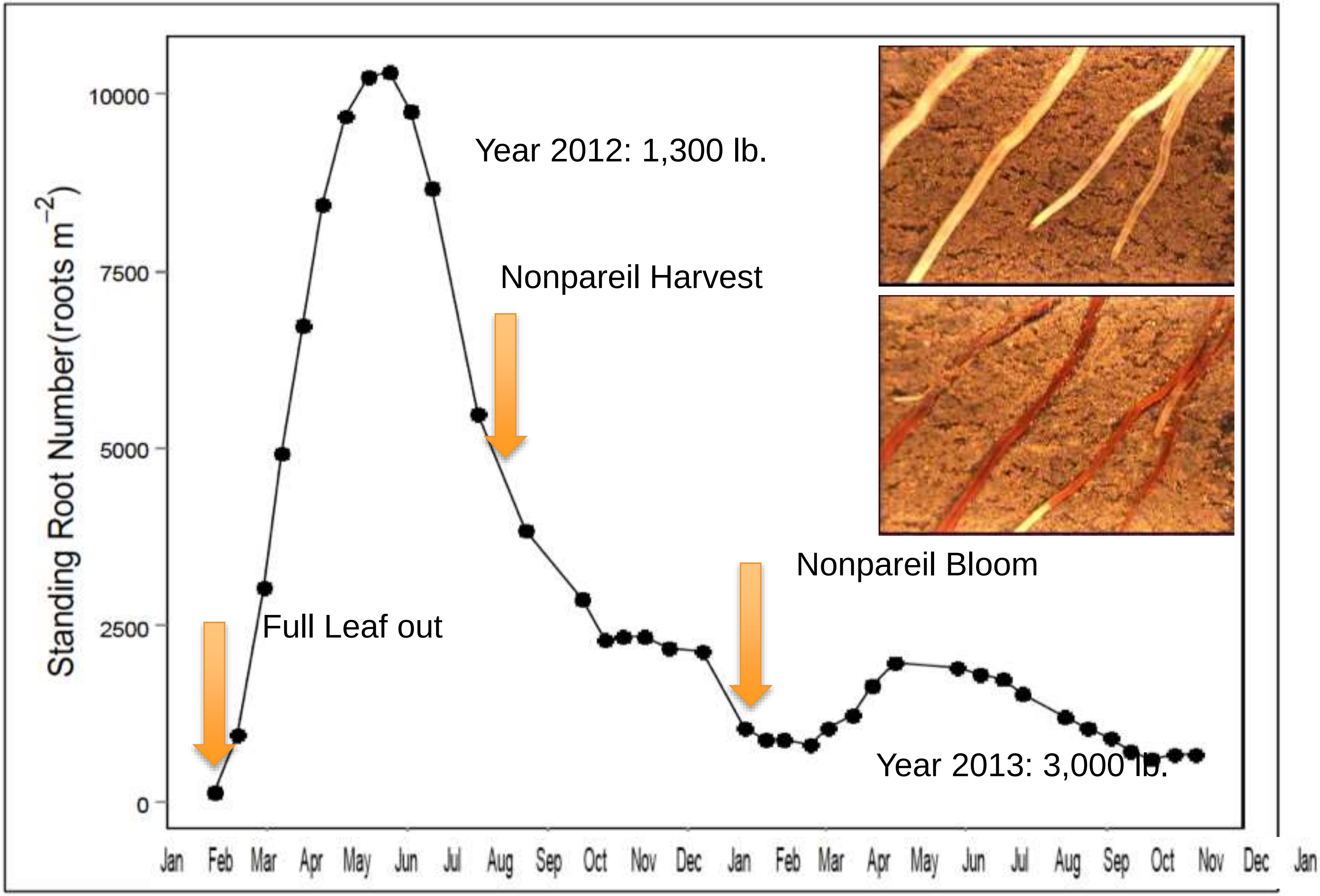

06/01


06/14

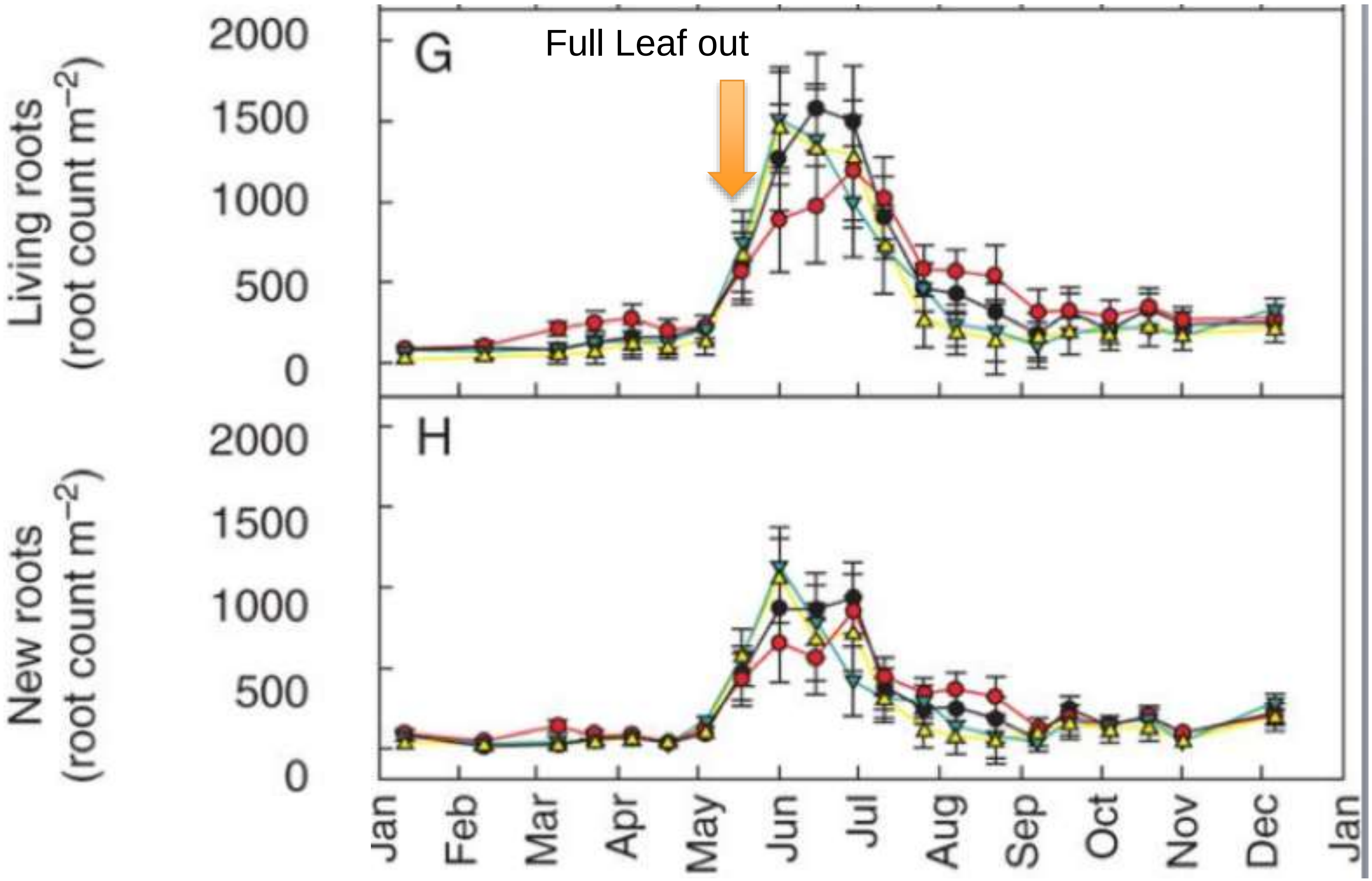
New Root Growth: Almond



Total ‘Active’ Root Length: Almond

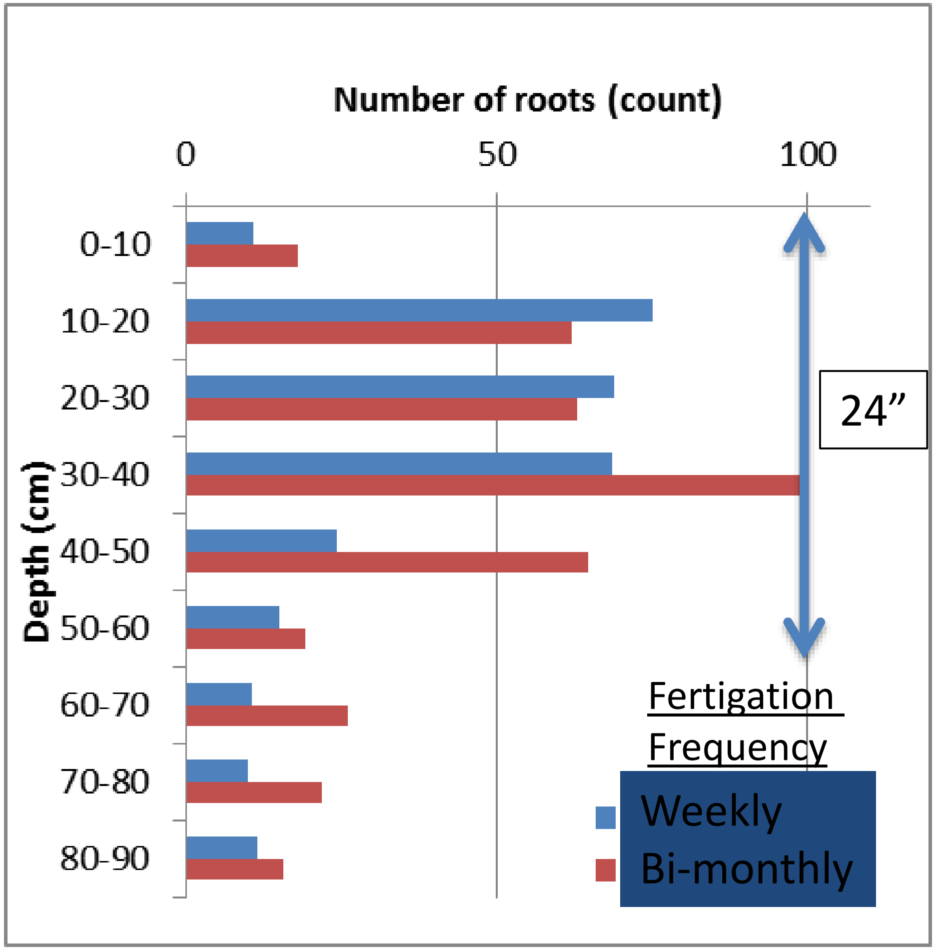


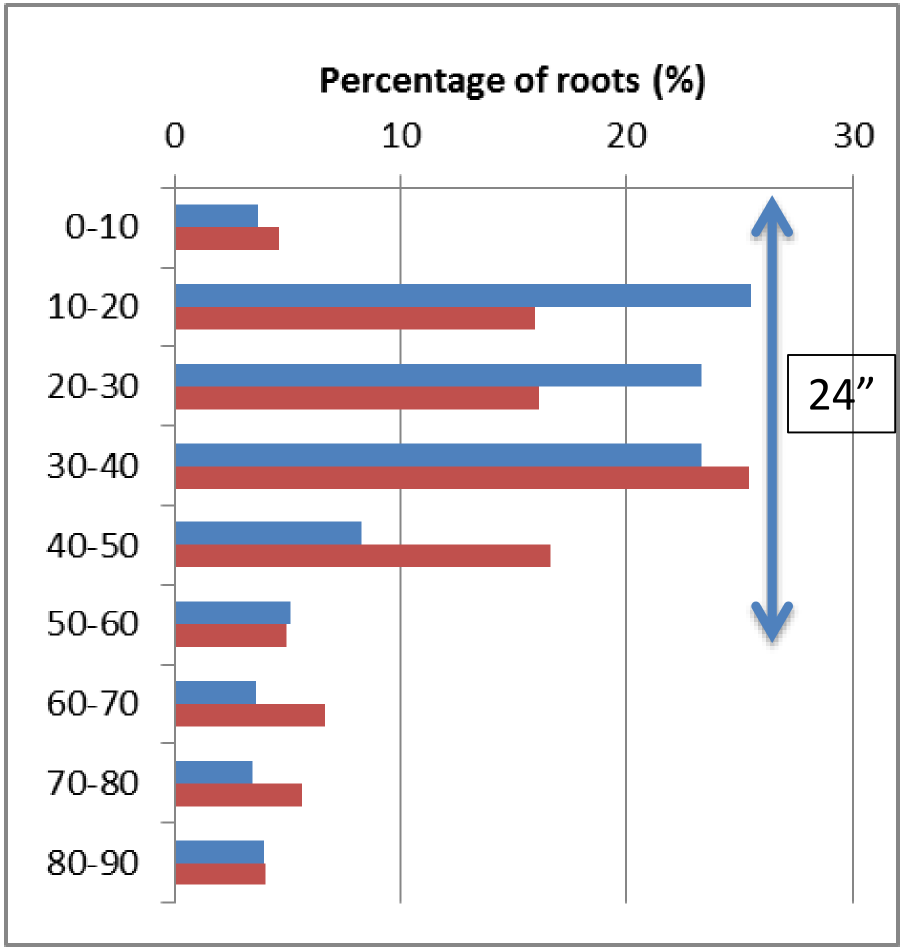
Root Growth Walnut



Contador et al 2015

Root distribution





How Effectively Can Roots Acquire Nitrogen Following a Fertigation Event

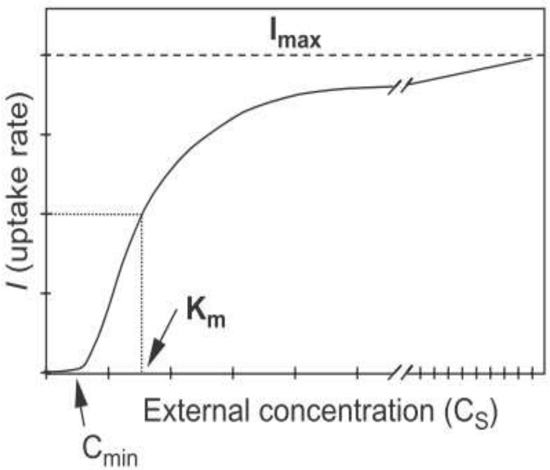
Root Uptake





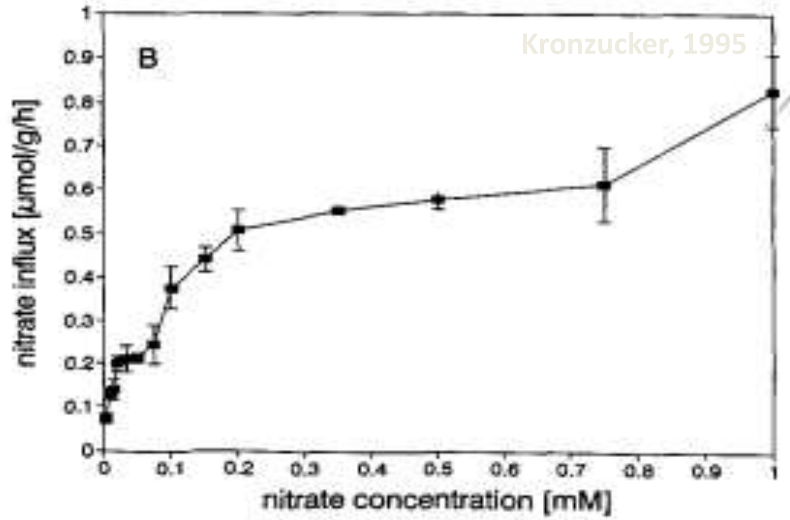

Uptake Estimation

Marschner, 1995

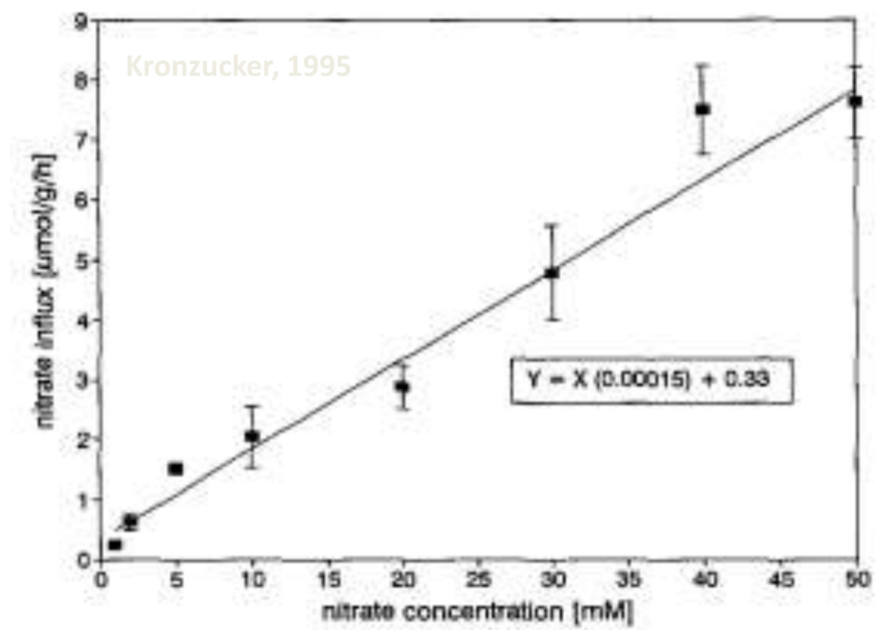


$$I = \frac{I_{max}(C_s - C_{min})}{K_m + (C_s - C_{min})}$$

Kronzucker, 1995



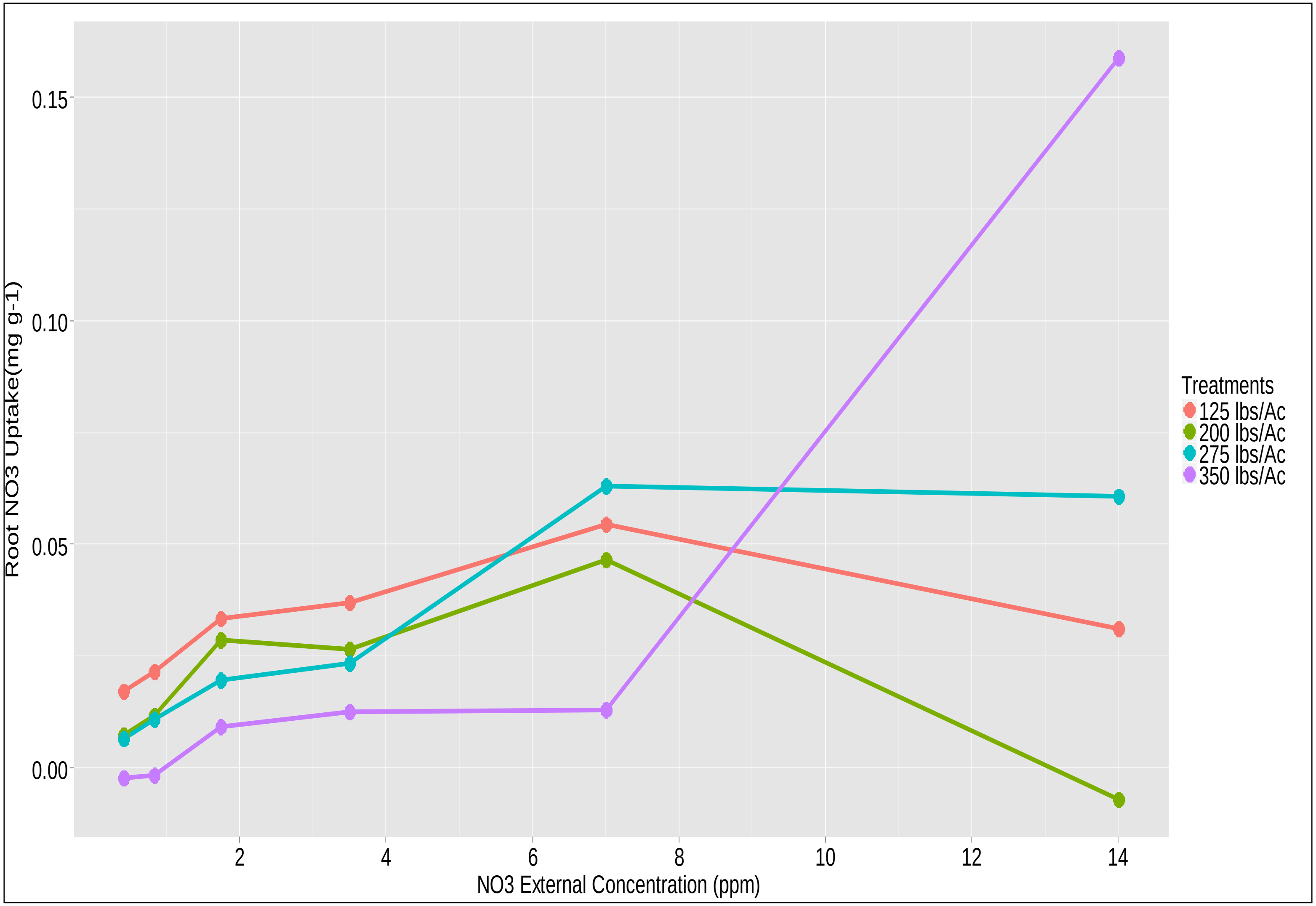
Kronzucker, 1995



- I = Influx
- I_{max} = Maximum influx
- C_s = Soil solution concentration
- C_{min} = Minimum concentration
- K_m = Michaelis-Menten constant

N-NO3 Uptake on Almond Roots

Root Nitrate Uptake (mg.g.hr)



External Nitrate Concentration (ppm)

Summary: Root Growth

- New root growth commences during late bloom and continues through full leaf out
- Peak root activity occurs during nut-fill then diminishes as nuts approach harvest.
- A small peak of new root growth occurs in early winter in some years.
- The vast majority of active roots were found in the 0-18” depth, which in this orchard was the depth of soil wetting during an irrigation event.
- Uptake of nitrate by roots is influenced by nitrogen rate provided. The ability to uptake N from low N soils is diminished in trees that are rich in N, while the rate of uptake of N is enhanced at high soil N values in trees that are rich in N.

How does the schedule and type of fertigation influence N leaching and uptake?

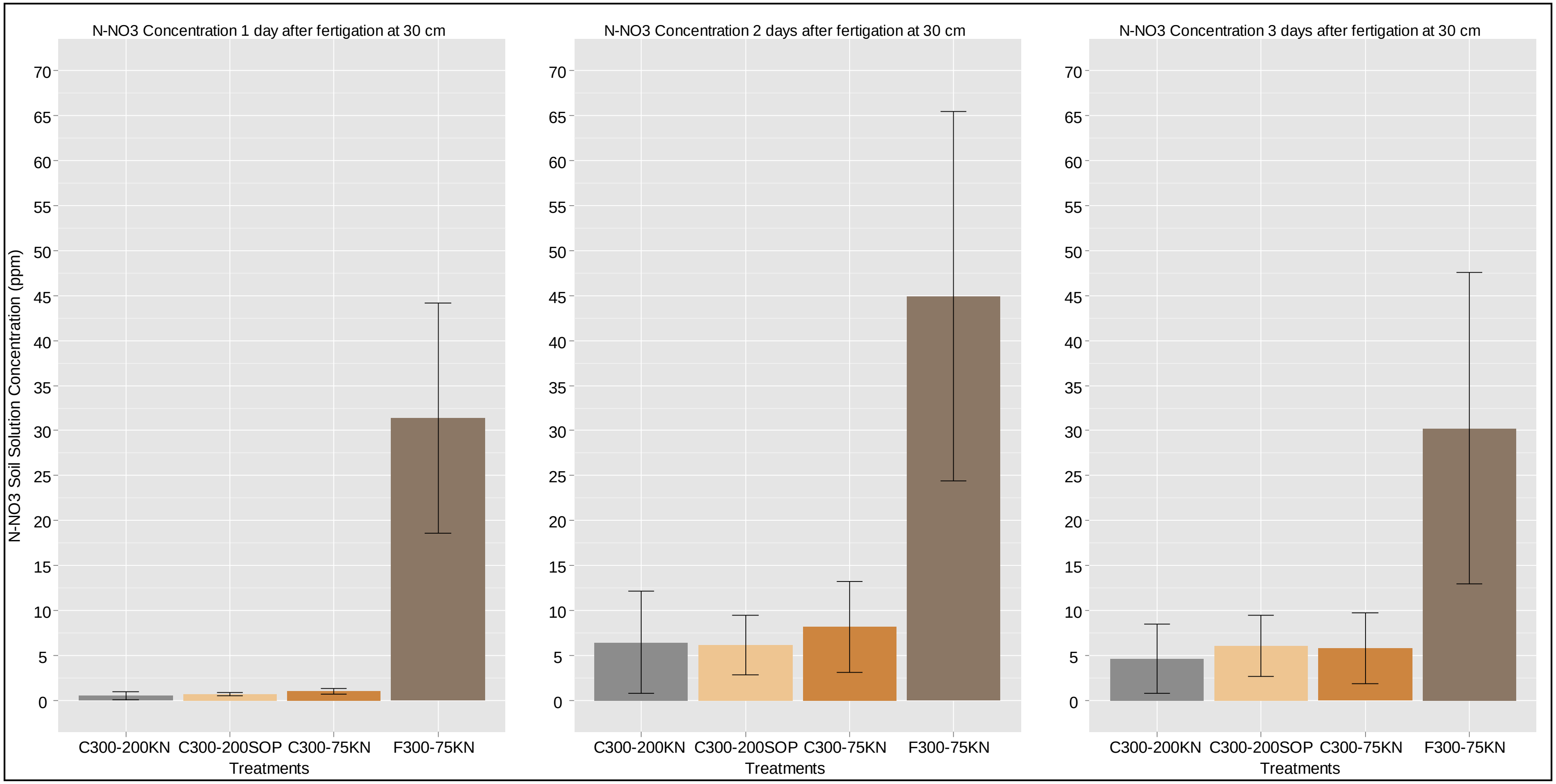
Treatment description

Treatments	K Source (%)				N Source (%)	
	SOP	KNO3	KCl	KTS	KNO3	UAN
F300-75KN-125 SOP	62.5	37.5	0	0	9	91
C300-200SOP	100	0	0	0	0	100
C300-75KN	62.5	37.5	0	0	9	91
C300-200KN	0	100	0	0	36	64

F= Fertigated in 4 seasonal applications in Feb, Mar, Jun and Sept.
C= Fertigated in every irrigation event.

Measurement of Nitrate in soil following irrigation utilizing a suction lysimeter.

First Fertigation at 30 cm



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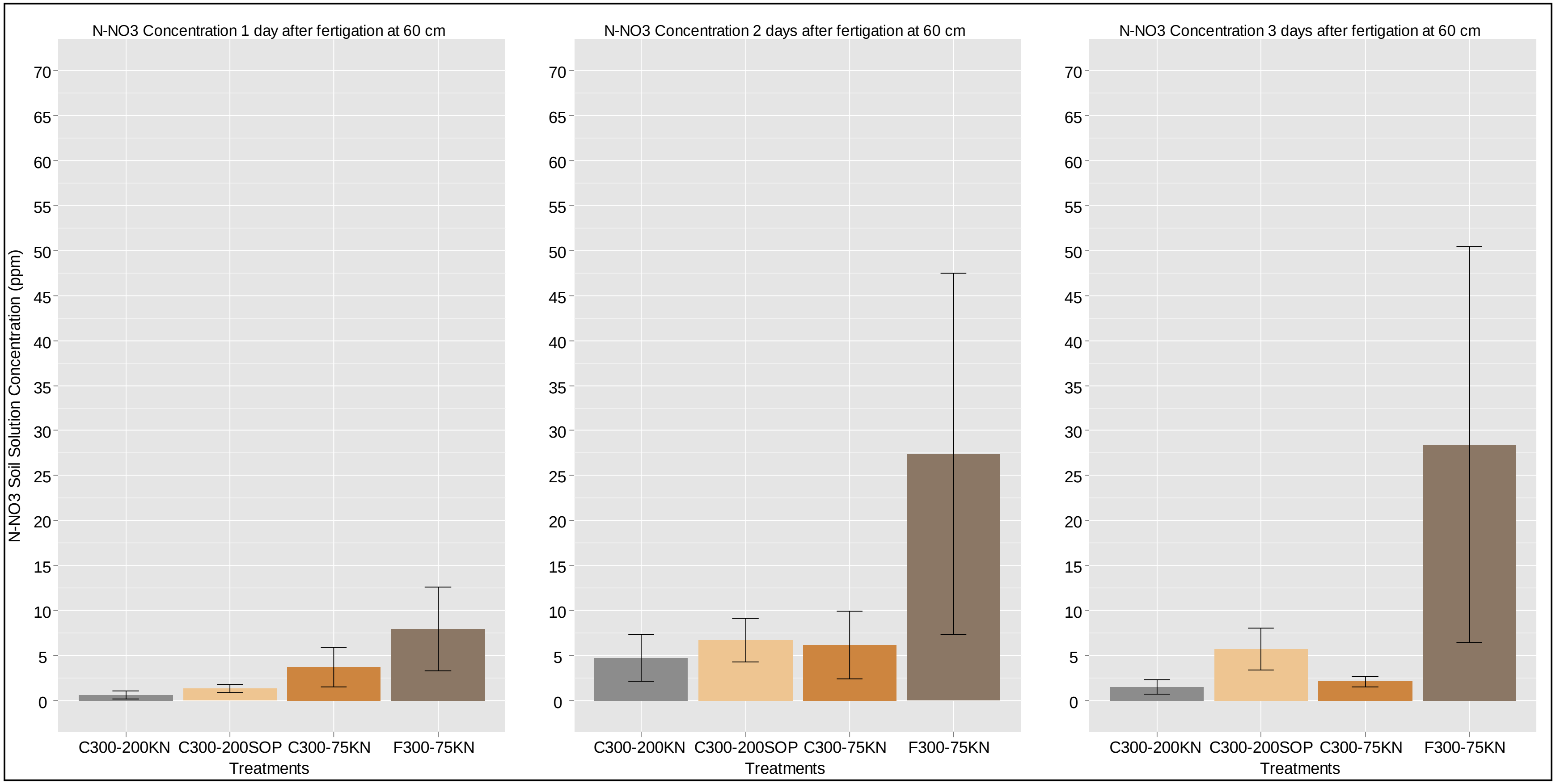
C= Fertigated in every irrigation event.

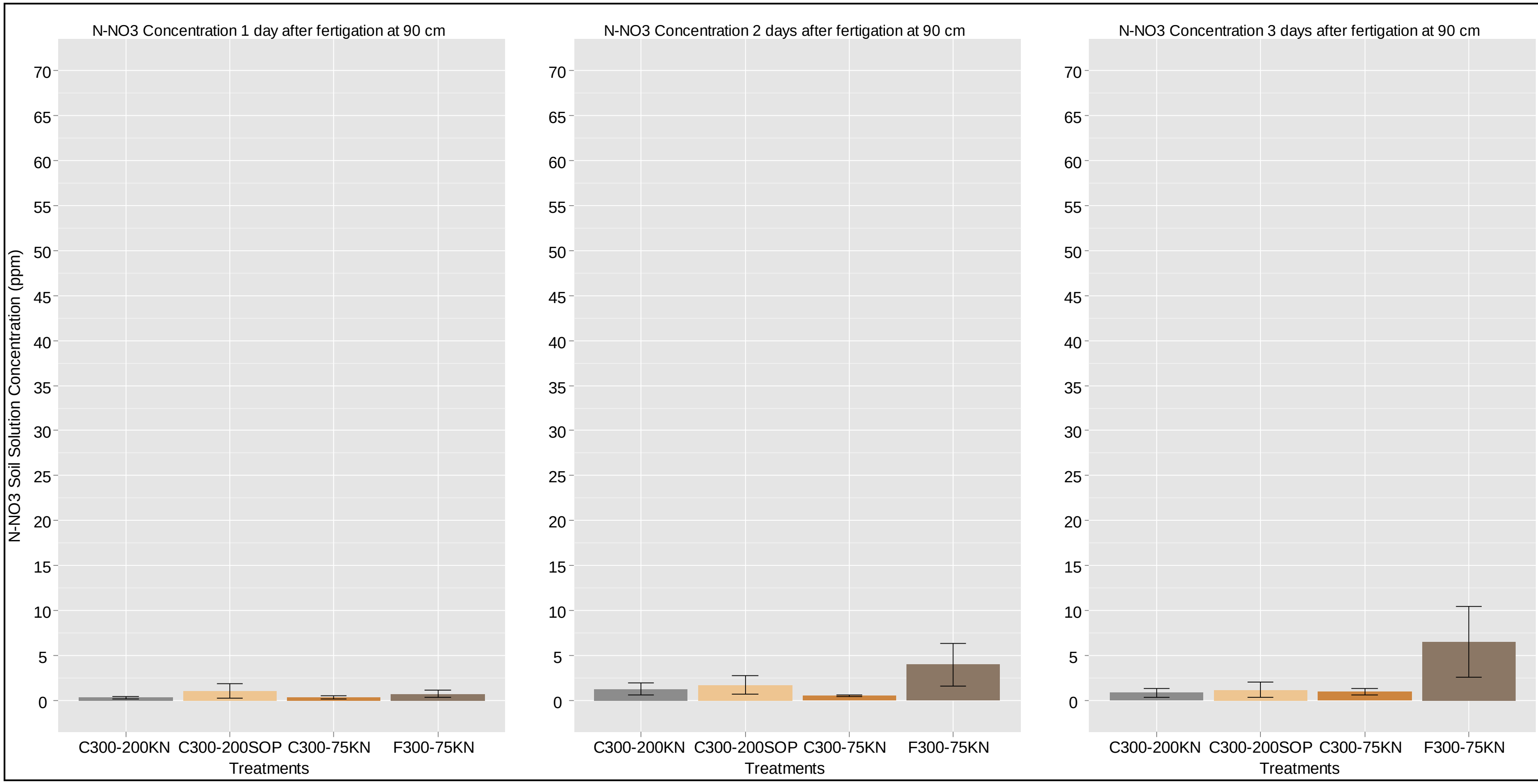
First Fertigation at 60 cm



F= Fertigated in 4 seasonal applications in Feb, Mar, Jun and Sept.

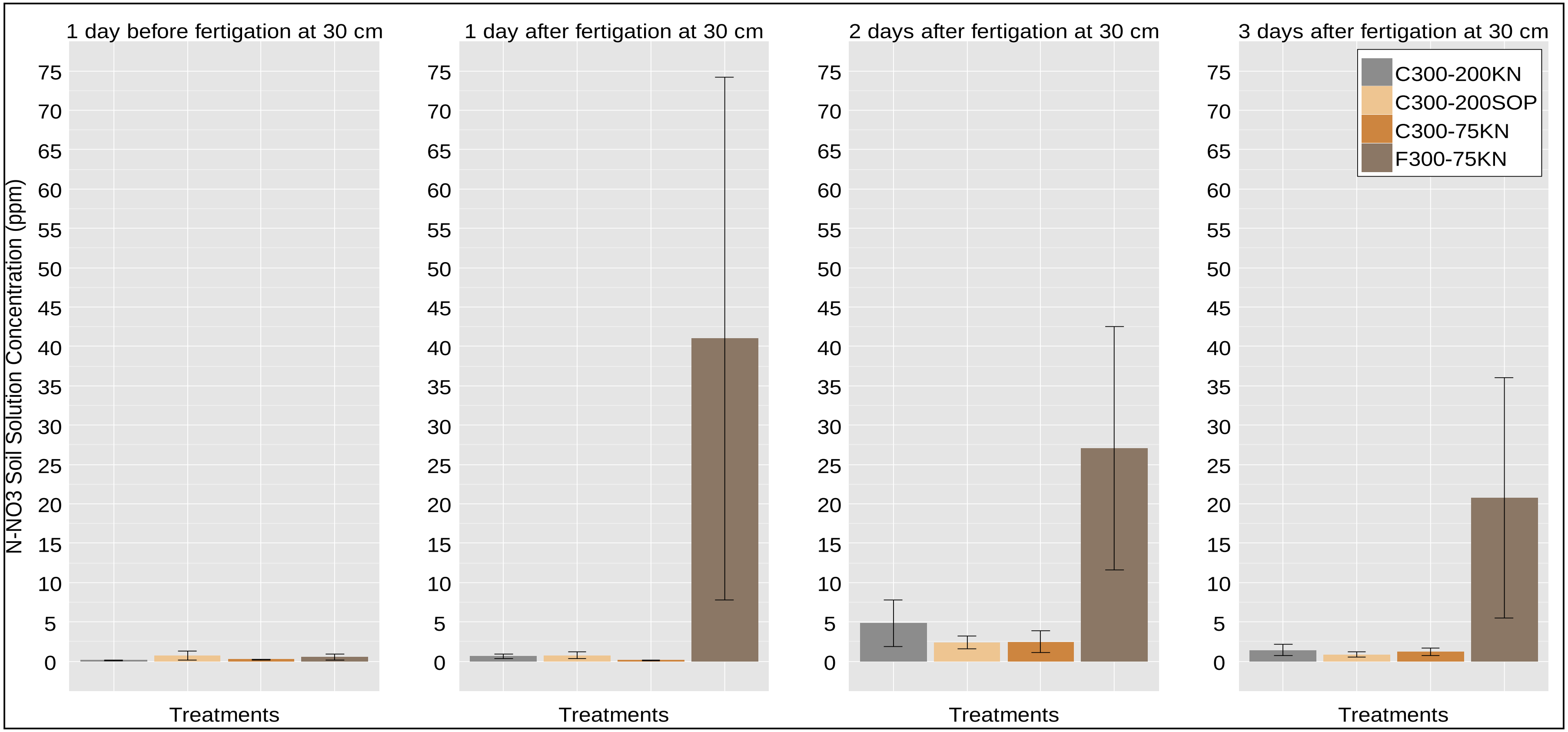
C= Fertigated in every irrigation event.

First Fertigation at 90 cm



F= Fertigated in 4 seasonal applications in Feb, Mar, Jun and Sept.
C= Fertigated in every irrigation event.

Second Fertigation at 30 cm



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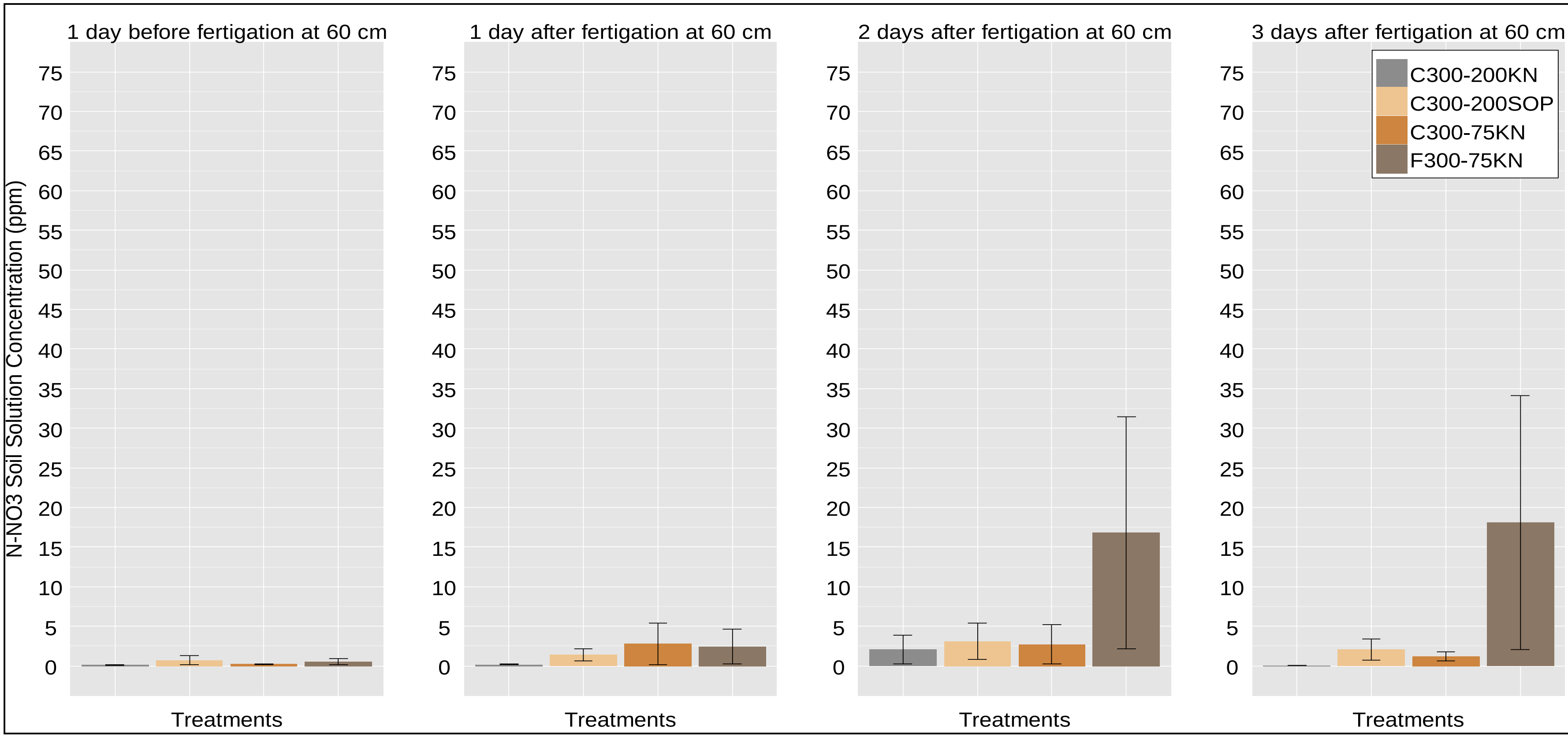
Second Fertigation at 60 cm



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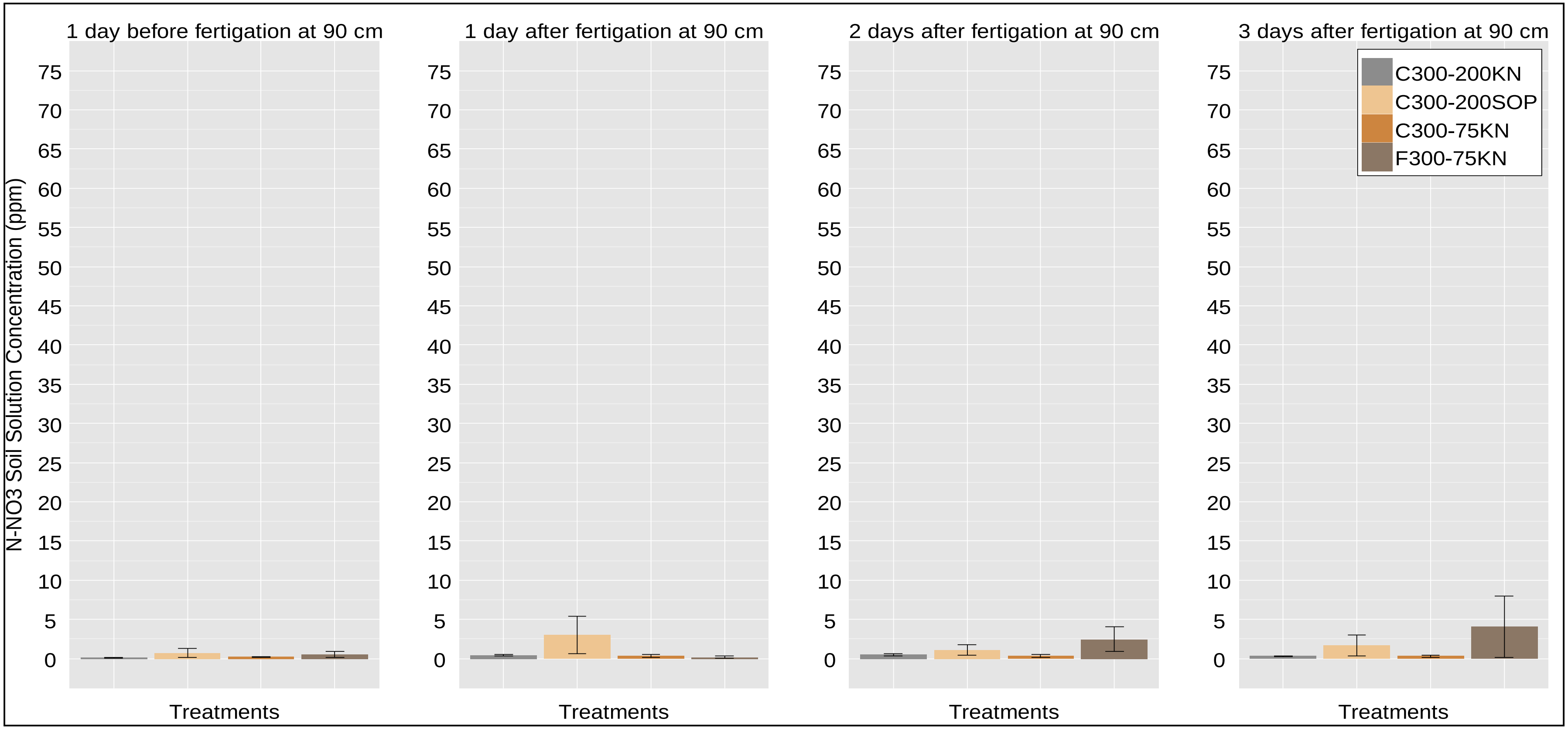
Second Fertigation at 90 cm



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C= Fertigated in every irrigation event.

Conclusions

- There is a large variability in NO3 concentration within the samples.
- Continuous fertigation treatments reduce NO_3 concentration at all depths and times.
- If deep leaching does not occur, N supplied from infrequent fertilization events can be recovered.
- Soil solution sampling is highly variable and difficult to obtain from dry soils.

How Does The Timing Of The Fertigation Pulse Influence Nitrate Movement?

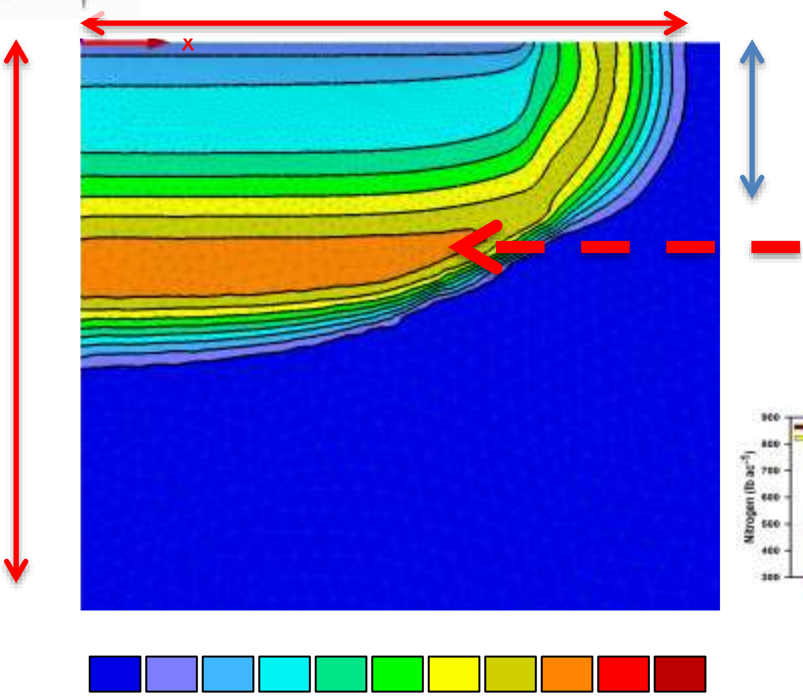
Right Place: Impact of Fertigation Timing on Nitrate Uptake by the Tree

Fertilizer Injected at hours 3-6 hrs during a 24 hour 1.5” irrigation.

Image shows nitrate remaining in the profile 21 days after fertigation event illustrating how poor fertigation timing results in loss below root zone.

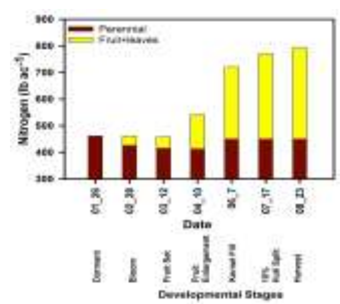
60”

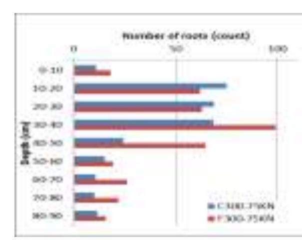
60”

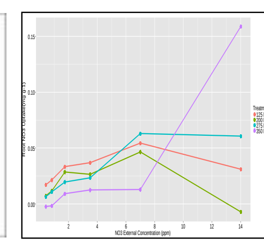


18 “ Effective Root Zone

Nitrate accumulated below effective root zone.







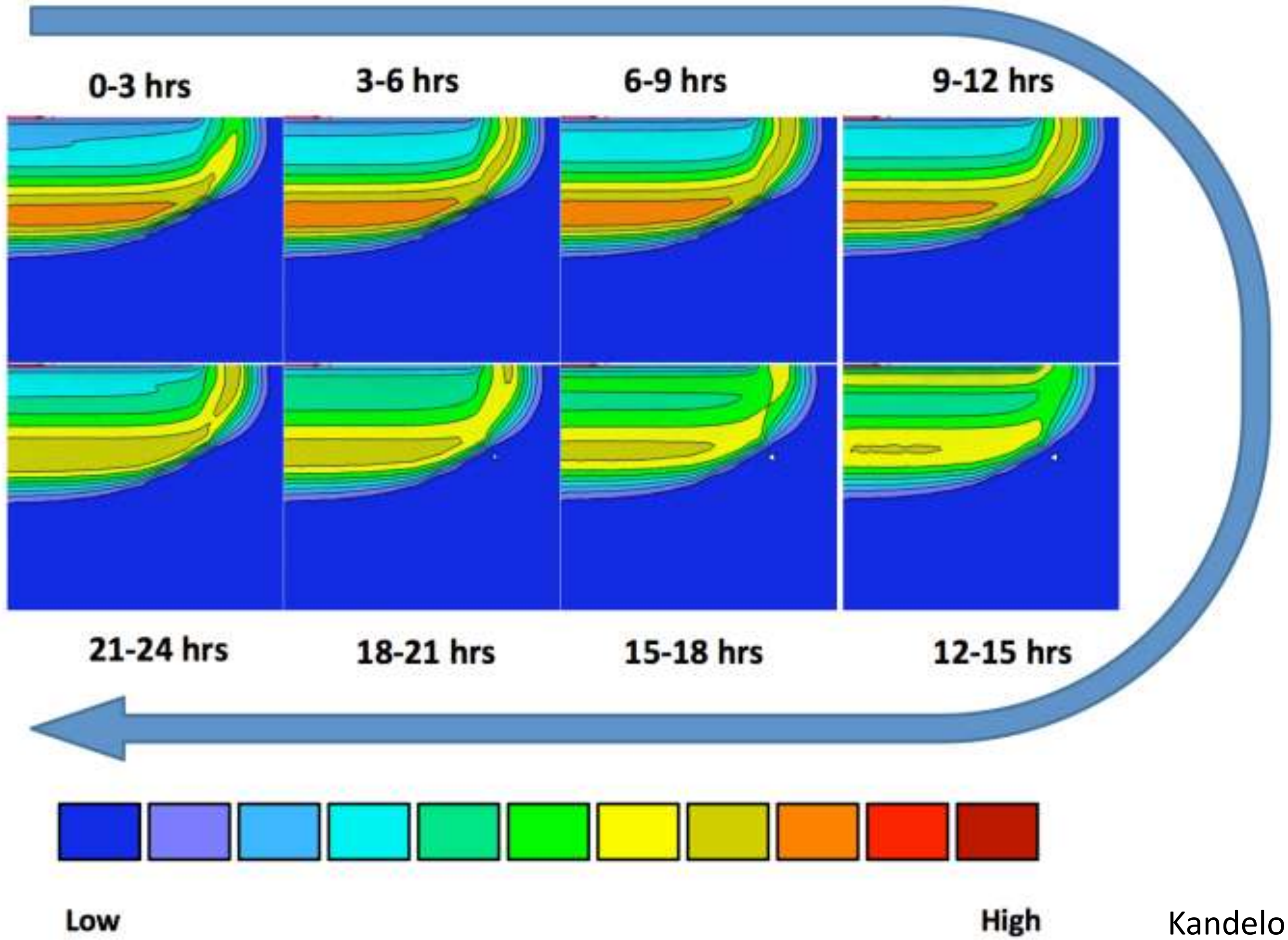
ppm Nitrate

2 4 6 8 10 12 14 16 18 20 22

Kandelous, Unpublished

Right Place: Impact of Fertigation Timing on Nitrate Uptake by the Tree

Each of these 8 images represents a 3-hour fertilizer injection event (day 0) that occurred during a 24 hour 1.5” irrigation event. This was followed by two additional irrigation only events on days 7 and 14 for 4.5” total. The image below represents nitrate in the profile at 21 days after the fertigation, prior to the subsequent fertigation.



Kandelous, Unpublished

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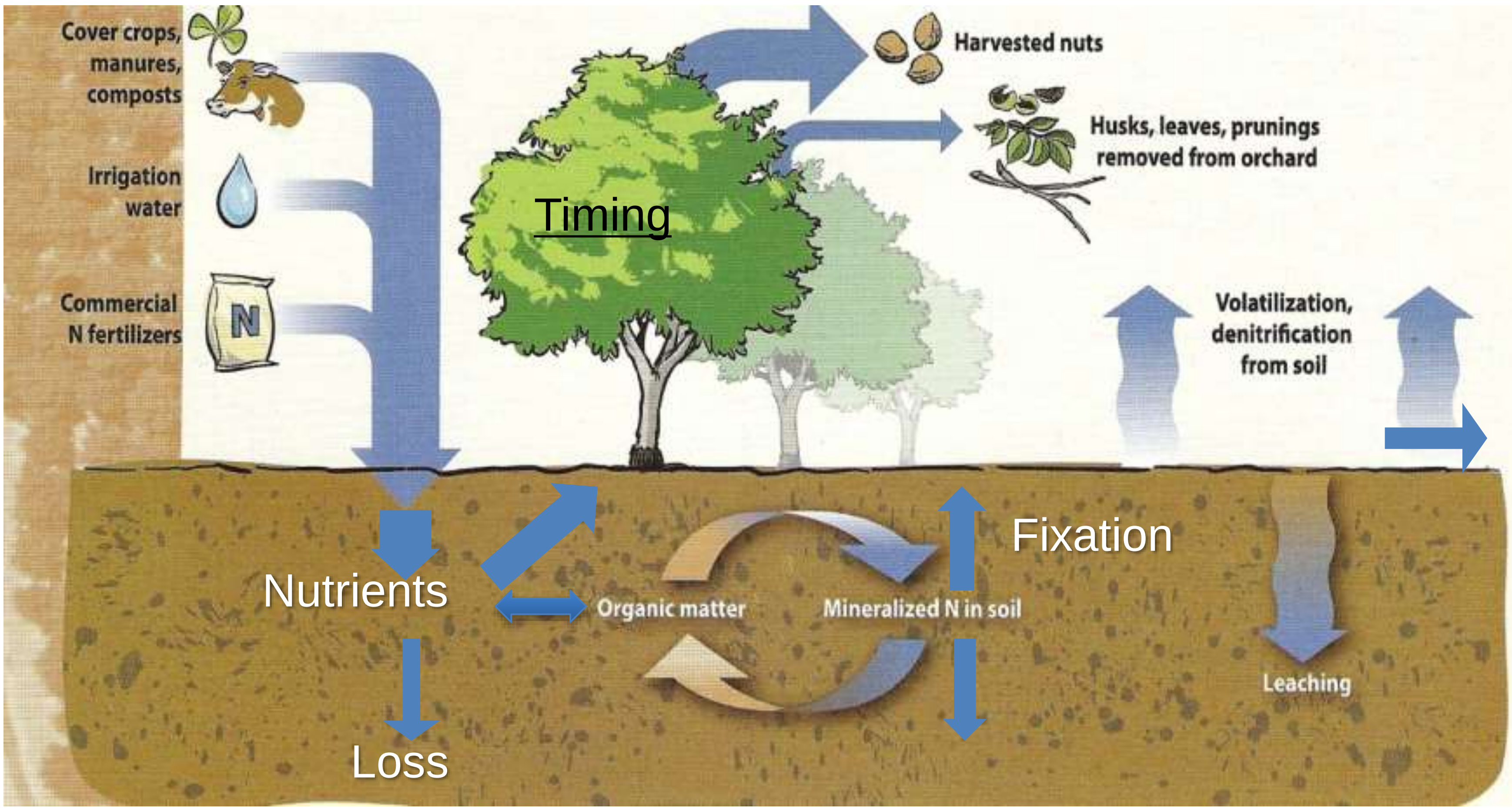

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  - Lan Le
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  - Jan Hopmans
  - Maziar Kandelous
  - Armen Malazian
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  - Bruce Lampinem
  - Sam Metcalf
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